Implementing OP-alternative pest management programs in Washington apple

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Introduction and Regulatory History

A decision by the EPA to phase out azinphos-methyl (AZM, Guthion) by 2012 signals the end of this product's use by tree fruit growers (Table 1). AZM belongs to a class of insecticides, the organophosphates (OP), that has been the primary target for regulatory review by the EPA following passage of the Food Quality Protection Act of 1996. AZM has been the most used insecticide in apple since the late 1960's primarily as a control for the key pest of apple, the codling moth (CM, Figure 1).

Figure 1. *Adult Codling Moth*

In recent years AZM, and other OP insecticides, have been cited as being detrimental to farm worker health and in 2004 Washington implemented a cholinesterase-testing program to help monitor potentially negative side effects for pesticide applicators using OP products. AZM is not the only OP insecticide under regulatory scrutiny. Imidan (phosmet), Lorsban (chlorpyrifos), Diazinon (diazinon), and Malathion (malathion) will each face further regulatory review due to their negative impact on the environment and farm worker safety.

Table 1. *Guthion Phase Out in WA Apple (2008-2012)**

2007	Limit to 4 lb ai/A
2008-2009	Limit to 3 lb ai/A
2010	Limit to 2 lb ai/A
2011-2012	Limit to 1.5 lb ai/A

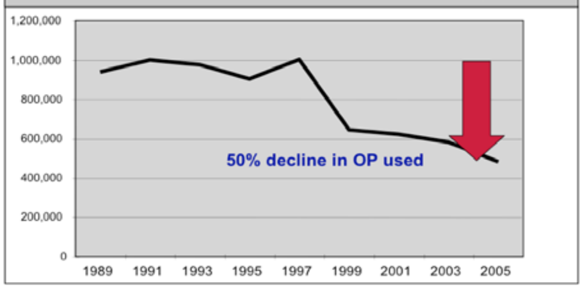
****Northwest Horticulture Council (http://www.nwhort.org/nhcpublic/guthion%20alert-3.html)***

While the EPA has been active in reviewing and restricting the use of OP insecticides over the past decade, it has also registered many new insecticides and miticides. As a result, there are now more insecticides and miticides registered for use in tree fruit crops than ever before. The availability of a large number of new products with new modes of action will require growers to change their standard practices. Most of the new products are very low in toxicity to humans and, in a relative sense, are safer to the environment than those they are intended to replace. The new products are more selective, meaning they affect specific insects or mites when a susceptible life stage is targeted. In some cases, because many insects and mites have developed resistance to OP products, the OP replacement may have a more extensive affect on the orchard ecosystem than the product that is replaced. This can add value to a pest management program, but can also be detrimental if the insect or mite affected was serving a beneficial role. In contrast to the OP products, which are active against insects that crawl across or consume residues, the insecticidal activity of the OP-alternatives generally does not occur until after the products have been consumed or when the products come into direct contact with the egg. The practical implication of these characteristics of the OP-alternative insecticides is that their application timing must be more precise with coverage that is better than most products growers have used previously. In addition, most of the new products are more expensive than the OP products they will replace and will be expected to increase pest management costs.

Figure 2. *Decline in OP Use in WA Apple*

2005 National Agriculture Statistics Service Survey

Chemical	% area	No. appl.	Total pounds AI
Guthion	72	1.8	196,400
Lorsban	58	1.1	186,700
Imidan	15	1.4	87,100
Diazinon	5	1.0	13,300



OP-Alternatives for CM and LR in Apple

The amount of OP insecticides being used in Washington apple has been reduced by 50% since the passage of the Food Quality Protection Act in 1996 (Figure 2). This is due, in part, to regulatory review and increased restrictions imposed by the EPA, but also because Washington growers have made a conscientious choice to use OP-alternative insecticides and pheromone mating disruption products that are safer for farm workers and the environment. Guthion, Lorsban, Diazinon and Imidan are the four OP products still in use in Washington apple. Guthion and Lorsban account for 80% of this use. These two products are used primarily to target CM and leafroller (LR) for which there are now a number of effective OP-alternative insecticides registered for use.

Two new products, that are expected to be registered in time for use during the 2008 field season, will be very useful in implementing OP-alternative pest management programs in Washington apple. ***Altacor™*** (rynaxypyr) is being developed by DuPont Crop Protection and is currently being reviewed by the EPA for registration as a reduced risk insecticide. Altacor™ represents a novel class of insecticides (the anthranilic diamides), which acts on the insect muscle. ***Delegate™*** (spinetoram) is being developed by Dow AgroSciences and is also currently being reviewed by the EPA for registration as a reduced risk insecticide. Delegate™ is a new spinosyn insecticide (same class as Success and Entrust) and acts on the insect nervous system. Including these two soon to be registered products, there are five different classes of OP-alternative insecticides representing nine different modes of action that will be registered for use in Washington apple for control of CM and/or LR (Figure 3). Successfully replacing the OP insecticides that are currently being used will require that users understand how the new products work (their mode of action) and know which pests and life-stages each product controls. Creating sustainable pest management programs with these products will require a strategic plan that will take advantage of the products' potential to control multiple pests and realize the improved activity of the products through optimizing application timing and tank-mixing modes of action. In addition to developing a strategic plan to optimize pest control, it will also be important to intentionally plan pest control programs that minimize resistance development to these new products so that they will remain useful in our pest management programs for as long as possible.

Figure 3. *OP-alternative Insecticides*

Insecticide	Class	Activity
Assail	neonicotinyl	disrupt nerve transmission
Calypso		
Rimon	insect growth regulator	chitin inhibitor
Intrepid		molt accelerator
Esteem		juvenile hormone mimic
*Delegate**	spinosyn	disrupt nerve transmission
Success		
Proclaim	avermectin	disrupt nerve transmission
*Altacor**	anthranilamide	disrupt muscle action
HMO	biologicals	asphyxiant
Virus		viral infection
BT		bacterial infection

*Delegate and Altacor are expected to be registered in 2008

OP-alternatives for CM Control

CM Mating Disruption

A key to successful CM control with OP-alternatives is the ability to disrupt the CM life cycle in multiple places (Figure 4). CM over-winter as mature larvae protected in hibernacula under loose bark scales on the tree or under leaf litter at the base of the tree. The first opportunity to begin a control program for this pest is to target the adult moth. Very few insecticides currently registered have activity against adult CM; however, CM mating disruption products (Figure 5) that are applied before moths begin to emerge can be very effective at disrupting mating and thereby limiting the number of CM eggs that are deposited in the orchard. Reducing egg deposition results in a smaller CM population that will need to be controlled with insecticides. All insecticide programs appear to perform better when used in combination with CM mating disruption. We estimate that seventy-five percent of Washington's bearing apple acreage is currently using CM mating disruption, which is a good indication that many Washington growers are already well prepared to begin using OP-alternative insecticides to supplement their pheromone-based CM programs.

Figure 4. *Interrupt the CM Lifecycle*

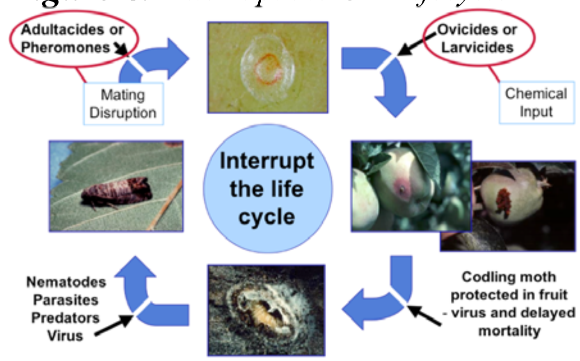
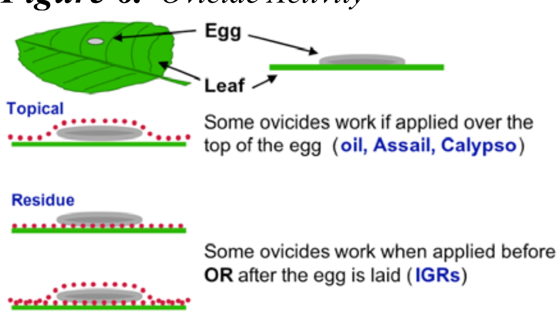


Figure 5. *Isomate C+ Pheromone Dispenser*

CM Ovicides

The next susceptible life stage in the CM life cycle is the egg. Traditional CM control programs have focused on control of the CM larvae. OP-alternatives allow growers to use insecticide applications to specifically target the egg stage, effectively reducing or eliminating eggs that otherwise would have hatched.

Figure 6. *Ovicide Activity*



Ovicides are insecticides that kill eggs. Some ovicides, horticultural mineral oil (HMO) and the neonicotinyls [Assail (acetamiprid) and Calypso (thiacloprid)], work only if applied over the top of the egg (topical). Others, the insect growth regulators (IGR) [Esteem (pyriproxyfen), Intrepid (methoxyfenozide) and Rimon (novaluron)], can provide residual as well as topical control (Figure 6). When HMO is used as an ovicide against CM, the optimal application timing is just prior to the beginning of the egg-hatch period, 200 degree-days (DD) past first moth flight (biofix). Repeat applications at 200 DD intervals are necessary to control eggs deposited after the initial HMO application. The ovicidal activity of Assail and Calypso add value to their control activity when applied at the more typical egg-hatch timing (250 DD). The IGR insecticides allow more flexibility in application timing because they effectively control eggs that are deposited on top of residues as well as eggs that are covered when the application is made. Optimal timing for these products to control CM is between 75 and 200 CM DD. The IGR insecticides also kill overwintering LR larvae that are active during this time period. The flexibility in CM timing with these products allows growers the opportunity to focus on optimizing LR application timing without compromising CM control.

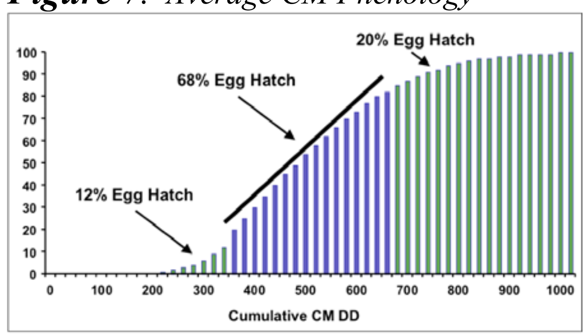
CM Larvicides

Larvicides are insecticides that kill larvae. CM larvae find and enter the fruit very shortly (hours) after hatching. OP insecticides kill larvae when they crawl across or consume residues of the product applied. CM larvae must consume the residues of the OP-alternative larvicides (Assail, Calypso, Intrepid, Delegate, Altacor, and granulovirus) before these products are effective. Traditionally, larvicides have been applied at the very beginning of the CM egg-hatch period (250 DD) and then reapplied based on the expected residual life of the product being used. Many of the OP-alternative insecticides have a shorter residue life than the OP products that they are replacing. To help compensate for this fact and to further optimize their efficacy as larvicides, an ovicide applied before the onset of the egg-hatch period is recommended. This strategy delays the egg-hatch period thereby shortening the period of time when larval control is necessary.

Optimizing CM Larvicide Timing

Codling moth degree-day model predictions show that average CM egg-hatch begins approximately 230 DD past biofix (Figure 7). The hatching of deposited eggs starts off slowly and in the first 10-15 days (100DD) only 12-15% of the total egg hatch occurs. The rate of egg hatch then becomes more rapid and in the 21d period after 350 DD almost 70% of the eggs hatch. After this period of peak activity, the rate of egg hatch slows and the final 15-20% of the first generation egg hatch occurs over about a two-week period.

***Figure** 7. Average CM Phenology*

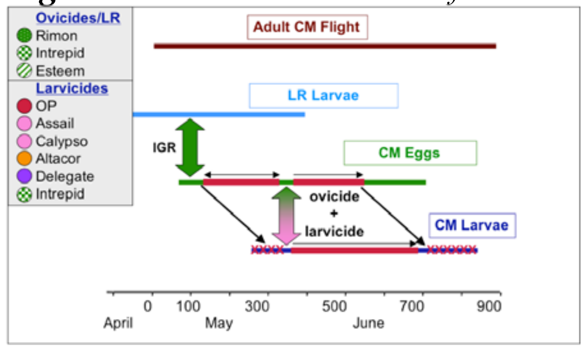


The potential problem with the traditional larvicide application strategy is that the most active residues from the first application are in the orchard at a time when relatively little CM egg hatch is occurring. As a result the weakest residues from the first application occur during the period of peak egg-hatch activity, when the potential for injury accumulation is the highest. By applying an ovicide just prior to the onset of the egg-hatch period and delaying the larvicide application to 350 DD the most active larvicide residues coincide with the most active egg-hatch period. In this strategy the ovicide kills eggs that would have hatched in the period starting at 230DD allowing growers an opportunity to delay the first larvicide application until 350 DD, which is the beginning of the period of peak egg-hatch activity. This strategy also shortens the period of time that larval control is necessary, which may be more accommodating to the OP-alternative larvicides that, in general, have a shorter residual life than the OP insecticides that they are replacing.

Tank-Mix Strategy

One CM control strategy that takes advantage of the multiple modes of action of the OP-alternative insecticides is to combine two insecticides with different modes of action in the same tank. Using a tank-mix strategy that combines an ovicide and a larvicide can enhance CM control by killing both eggs and larvae that are present in the orchard with a single application (Figure 8). In this strategy, an ovicide (IGR or HMO) is used before the egg-hatch period begins allowing a delay of the next application until 350 DD. A tank-mix (ovicide plus larvicide) application at this time kills eggs that are deposited after the earlier ovicide application as well as eggs that will be deposited on top of the ovicidal residues from the tank-mix. The larvicide in the tank-mix kills any larvae that successfully hatch and then feed on residues. The added value of this approach comes when eggs that would have hatched once the residues of the larvicide had been depleted do not because they were killed by the residual activity of the ovicide in the tank-mix (Figure 8). The combined action of the ovicide and larvicide in the tank-mix extends the period of control from this single application to cover the entire first generation under average conditions.

Figure 8. *Tank-mix two modes of action*



Traditional LR Programs

Figure 9. *OBLR Larvae*

Traditional LR control programs begin with a Lorsban application at the delayed dormant (or half-inch green) stage of bud development. In recent years there has been a shift in LR species in most commercial orchards from pandemis (PLR) to obliquebanded leafroller (OBLR, Figure 9). Both LR species over-winter as small larvae in hibernacula in bark crevices or other protected areas on the tree. While the majority of PLR larvae have emerged from their hibernacula by the delayed dormant stage, OBLR do not complete their emergence until approximately three weeks later. As a result, the effective Lorsban residues decline prior to the full emergence of the OBLR population limiting the value of the delayed dormant treatment. New predictive models for both PLR and OBLR are available via the WSU Decision Aids System that will help growers improve timing for OP-alternative insecticides as well as improve decisions about when to sample for LR larvae to get a better estimate of population densities or efficacy of previous insecticide applications. Optimizing LR timing with OP-alternatives will make it possible to move away from a reliance on delayed dormant Lorsban for LR control.

OP-alternative Insecticides for LR Control

OP-alternative insecticides that control LR include Esteem, Intrepid, Rimon, Success (spinosad), Delegate, Altacor, Proclaim, and Bt (*Bacillus thruingiensis*). All of these insecticides should be timed to target the LR larval stage. Most of these insecticides work best against the fourth larval instar. Esteem is the exception and should be timed to target fifth or sixth instar larvae. Implementing the new LR DD models will be very important to precisely time LR controls for specific larval stages in the absence of a Lorsban treatment. These eight insecticides represent seven different modes of action, which allows many options for implementation of a good resistance management program. Proclaim, Success and Delegate act on the insect nervous system and are fast acting and highly toxic to LR larvae that feed on their residues. Altacor acts on the insect muscle and has provided effective control of feeding LR larvae in research trials. The IGR insecticides (Esteem, Rimon, and Intrepid) disrupt the normal development of the insect. Esteem, which acts as a juvenile hormone mimic, prevents the transition from the last larval stage to the pupa and should be timed to coincide with the presence of larger larvae (5th and 6th instars). Rimon interferes with the normal formation of the insect's cuticle after a molt causing immobility and excess water loss resulting in death. Intrepid causes the insect to initiate a molt that is lethal because it cannot be successfully completed. Rimon and Esteem have an extended time-to-kill but both are effective at reducing the subsequent LR generation. The full impact of a Rimon application may not be realized until 14-21 days after the application, whereas with Esteem the impact is often difficult to see during the overwintering generation. Esteem intoxicated larvae often do not die until they reach the pupal stage. Because pupae can be difficult to find, mortality is not always obvious. Bt products consist of a protein, the product of a bacterium, which is lethal to LR larvae after being consumed. Repeated applications of Bt may be necessary to achieve good control.

Optimizing OP-alternatives for CM and LR Control

Figure 10. *OP-alternative targets of activity*

Insecticide		Codling moth		Leafroller
		Ovicide	Larvicide	Larvicide
Assail	●	●	●	
Calypso	●	●	●	
Rimon	●	●		●
Intrepid	●	●	●	●
Esteem	●	●		●
Delegate	●		●	●
Success	●			●
Proclaim	●			●
Altacor	●		●	●
HMO	●	●		
Virus	●		●	
BT	●			●

The "Petal-fall" Application

Though OBLR emerge later than PLR, the optimal timing for a post-bloom insecticide application targeting the fourth instar is usually similar for both species. And, generally, this time period also overlaps with the beginning of CM egg laying activity. The traditional timing for the first post-bloom application has been at "petal-fall", which can be a somewhat subjective and variable period. Using predictive models will help growers to optimize application timing to coincide with the target stage of the pests present in their orchards. Proclaim, Altacor, Success and Delegate have no activity against CM eggs (Figure 10); however, if LR is the primary focus of this application, these products have the fastest time-to-kill of the available products and will be the best options for preventing fruit injury by overwintering LR larvae. The requirement that LR controls be precisely timed may make combinations with thinning or disease programs problematic.

If CM is the primary pest in the orchard and LR is a secondary consideration at this time, then an application of Esteem, Rimon, or Intrepid will provide good activity against overwintering LR larvae and first generation CM eggs when applied between 75 and 200 CM DD. The flexibility in CM timing with these products allows growers to optimize timing against LR based on the targeted species, PLR or OBLR, and the mode of action of the product chosen. Weather is an important factor in optimizing LR control with any of the OP-alternative products. An application that is followed by warm weather (65°F and above), which stimulates good feeding activity by larvae, will provide better control of LR larvae.

Summer Generations

LR and CM both complete two generations each year in Washington. The best tactical approach to controlling summer generations of these pests is to do a thorough job of controlling the overwintering generation (larvae) of LR and the first CM generation. The phenology of summer generations of both LR and CM will be less synchronized and may require more applications to achieve the same level of control. Further, products may have a shorter residual life in the summer months (especially the biologicals – granulovirus and Bt) because of their susceptibility to UV light and high temperature degradation. Strategies for control of the second generations of both pests will be similar to those employed in the first generations but the amount of insecticide input, and the selection of insecticides will depend on the products used previously. When choosing products for control of CM and LR in summer, careful consideration of a sound resistance management strategy should be followed. Exposing successive generations to insecticides that have the same mode of action should be avoided.

Implementing OP-alternative CM and LR Control Programs

Current CM/LR Control Standard

Washington apple growers have already come a long way in the process of transitioning to a pest management program utilizing OP-alternatives. A typical program for CM and LR control in apple includes: Lorsban and Oil applied at delayed dormant; CM Mating Disruption applied prior to bloom; Success applied at optimal timing for over-wintering LR larvae; Guthion applied at 250 CM DD; Assail or Calypso applied 21d later; Intrepid applied at optimal timing for summer LR control, which coincidentally controls second generation CM eggs; and Guthion applied to control second generation CM larvae (Figure 11).

Figure 11. *Standard CM and LR Control*

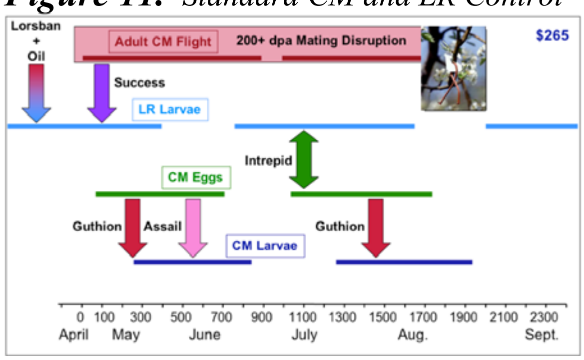
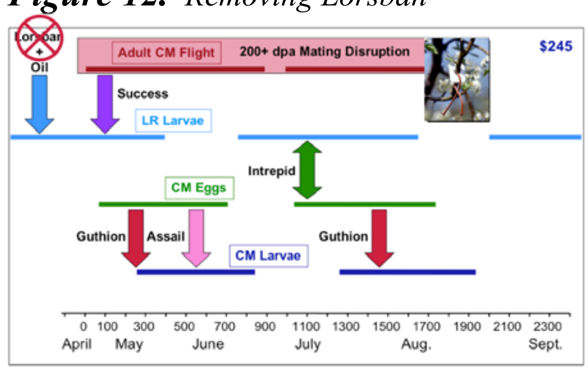


Figure 12. *Removing Lorsban*



Removing Lorsban from the Delayed Dormant Application

The easiest step in transitioning to an OP-alternative strategy is the elimination of Lorsban at the delayed dormant timing (Figure 12). Lorsban adds very little value to a CM/LR program at this timing. The species shift from PLR to OBLR reduces the efficacy of this timing for LR control and there are several OP-alternatives that can provide very effective LR control in the post bloom period. It is very important to retain the use of Oil at delayed dormant for control of secondary pests, especially San Jose scale (SJS) and European red mite (ERM) eggs.

Controlling Overwintering LR Larvae and First Generation CM Eggs

The first post-bloom application for controlling LR and CM requires careful planning and knowledge of the pest situation in the orchard. Two scenarios are presented here. In each of these scenarios, the intention is to provide control of LR larvae and CM eggs and to set up a control program for first generation CM larvae. The difference between these two programmatic approaches is the relative importance of each pest, which will require experience and knowledge of the particular location.

Scenario 1 – This scenario assumes that LR is a serious pest requiring a fast-acting insecticide to prevent fruit feeding in the spring. The OP-alternative choices currently registered for use are Success and Proclaim (Delegate and Altacor are expected to be available in 2008). The products should be used at the optimum model timing based on the LR species present in the orchard. These insecticides have no activity against CM eggs so there is no benefit gained against this pest and a CM specific program should be used. Oil (1% concentration) applied at 200 CM DD will kill CM eggs already deposited in the orchard and therefore delay the onset of significant egg-hatch. The oil treatment will allow growers to delay applications that target CM larvae by 100 CM DD, until 350 CM DD (Figure 13).

Scenario 2 – If CM is the primary concern and LR is still a pest of concern but secondary in importance, growers can choose an IGR insecticide that controls both LR larvae and CM eggs. The available products are Esteem, Intrepid, or Rimon. The timing for LR should be based on the optimum model timing for each product; Esteem is applied later than Rimon or Intrepid for best results. Because the IGRs kill CM eggs, their use will allow growers to delay the first larvicide application by 100 CM DD, or until 350 CM DD (Figure14). In this scenario the grower saves a trip through the orchard by eliminating the oil application.

Figure 13. *Oil to Delay CM Egg Hatch*

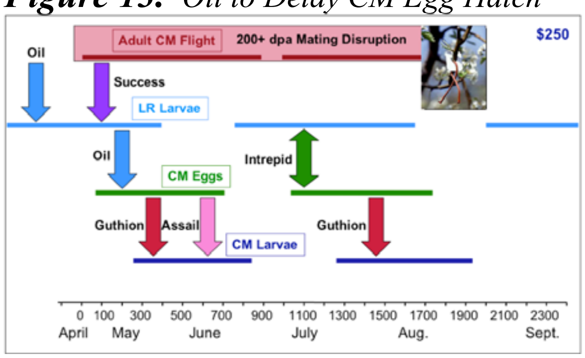
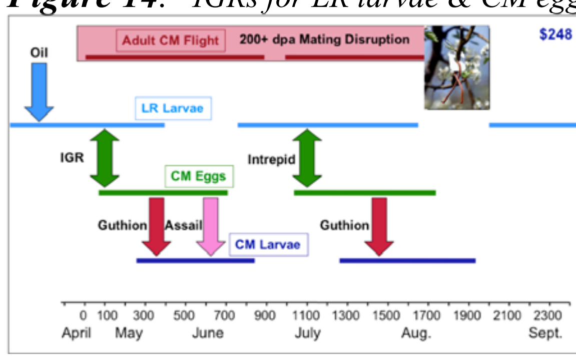


Figure 14. *IGRs for LR larvae & CM eggs*



Programs to control CM Larvae

OP-alternatives that effectively control CM larvae include Assail, Calypso, Intrepid, and two products that are expected to be registered in 2008 (Altacor and Delegate). The application timing for each of these products will be optimized by employing one of the tactics discussed in the previous two scenarios to delay significant egg hatch to 350DD. This delay shortens the period of time where larval control will be necessary. An application of Assail, Calypso or Altacor at 350 DD followed by a second application in 14-18 days would be expected to provide control of the remaining portion of the first CM generation. Intrepid and Delegate have a shorter residue life and re-treatment intervals with these products should not exceed 14 days. One approach for CM larval control that has proven very effective against high populations is to use a tank-mix of an ovicide (Esteem, Intrepid, or Rimon) with a larvicide (currently Assail or Calypso and Delegate or Altacor in 2008) (Figure 15). The tank-mix approach is set up by use of either an IGR in the post-bloom period or HMO applied at 200 CM DD, which will allow delaying the tank-mix treatment until 350 CM DD. The ovicide in the tank mix kills CM eggs deposited prior to the application as well as those deposited afterwards. The larvicide kills any larvae that were not affected by the ovicide treatment. This approach places the most lethal residues of both products during peak activity in the first CM generation. Usually another application is not required, however, CM monitoring programs that include adult traps and visual inspection of fruit for CM larval entries late in the first generation will determine if additional insecticide input will be necessary.

Figure 15. *Tank-mix Modes of Action*

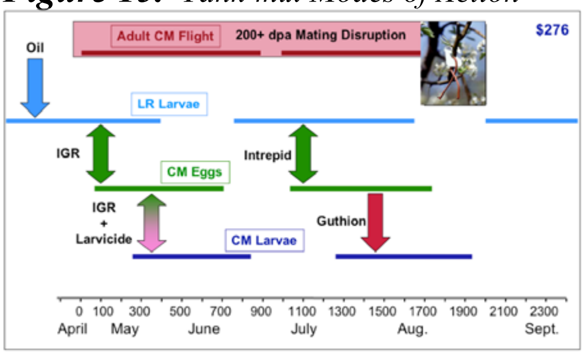
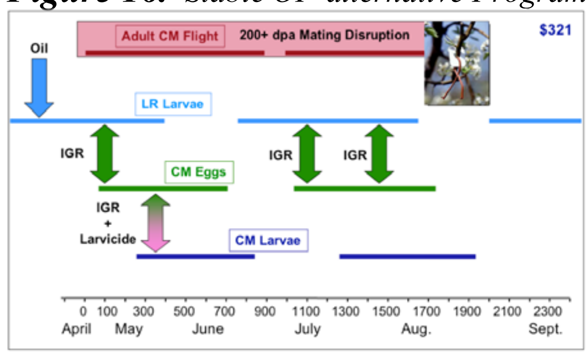


Figure 16. *Stable OP-alternative Program*



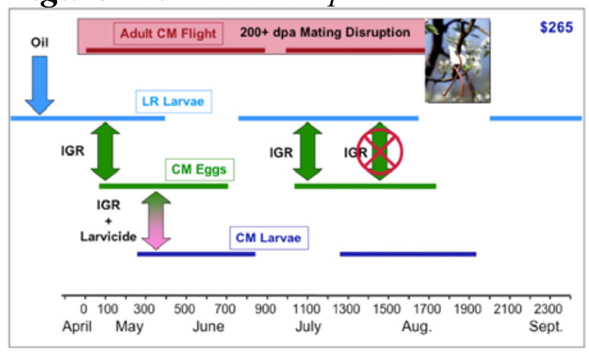
Second Generation CM/LR Control

Assuming that good CM and LR control is achieved in the first half of the season less insecticide input should be required in the summer. If summer LR control is necessary, that is a high carryover population is expected, then treatments should be applied at the beginning of the egg hatch period in order to minimize fruit injury. The new LR models will help in timing summer LR controls. The products of choice for this situation are Success, Proclaim, Bt, Rimon or Intrepid (Esteem should not be used for summer LR control). If Bt products are used repeat applications will most likely be needed as residues last only about 7 days in the summer. If an IGR (Rimon or Intrepid) is used some coincidental control of CM eggs is possible (Figure 15). However, if summer LR densities are expected to be low and the risk of fruit injury minimal, then treatments can be delayed until LR larvae are larger, fourth instar, and greater advantage of coincidental CM control can be achieved. A summer IGR targeting fourth instar LR larvae will allow growers to delay applications targeting CM larvae until 1350 CM DD. Larvicides (Assail, Calypso, Intrepid, Delegate, Altacor, or granulovirus) from any class not used in the first generation could fit here. An aggressive CM and LR control program in the first part of the season will provide an opportunity to use “softer” products in the second generation, for example, Bt for LR and granulovirus for CM or IGRs for both (Figure 16).

Reducing Insecticide Inputs

The costs of OP-alternatives is typically higher per application than products they replace making OP-alternative programs more expensive. However, the added value of safety, ease of worker management, and the opportunity to target multiple pests with one application may offset some of these costs. After an OP-alternative program has time to stabilize, there will likely be options for further reducing insecticide input (Figure 17). Increasing rates of CM mating disruption may also be an option for reducing the need for supplemental insecticide treatments.

Figure 17. *Reduced Inputs*



Secondary Pests

Changes in pest management programs will inevitably bring new challenges. In some cases, the challenges may come from secondary pests. For most secondary pests there are OP-alternatives that provide control (Figure 18). In some cases (e.g. woolly apple aphid and stink bugs) control will require using other traditional broad-spectrum insecticides such as Thiodan (endosulfan), Carzol (formetanate hydrochloride), or pyrethroids (Danitol, Warrior, Asana). In other cases, removing OP insecticides from a pest management program may result in a temporary increase in secondary pests that will be resolved by an increase in beneficial insects that had previously been suppressed by OP use.

Figure 18. *OP-alternatives for Secondary Pest Control*

Insecticide	Leafhopper	Campylomma	Green aphids	Rosy apple aphid	Woolly apple aphid	Thrips	Stink Bug	Grape Mealy Bug	San Jose Scale	Leafminer	Cutworm
Assail ●	●	●	●	●		●		●			
Calypso ●	●	●	●	●				●			
Clutch ●			●	●				●			
Provado ●	●		●	●				●			
Intrepid ●										●	●
Esteem ●				●					●		
HMO ●	●				●				●		
Success ●						●				●	
Avaunt ●	●										●
Danitol ●							●			●	
Warrior ●							●			●	
Asana ●	●						●			●	
Sevin ●	●										
Carzol ●		●				●	●				
Thiodan ●	●				●		●				

Resistance Management

Washington growers now have a number of OP-alternative options available for CM and LR control. The addition of two new products, Altacor and Delegate in 2008, will help with the ability to create strategic IPM programs that control CM and LR but also follow a sound resistance management plan. The key to conserving the efficacy of these new products will be to avoid their overuse. The use of CM mating disruption has been, and will continue to be, a very important means of reducing the need for insecticide input. In orchards with high CM pressure, it is likely that insecticide supplements will always be necessary. In choosing these supplements, it is important for growers to conscientiously avoid using insecticides with the same mode of action against more than one successive generation. The neonicotinyls (Assail, Calypso, Clutch, and Provado) all have slightly different pest activity profiles; however, their mode of action is very similar and they should be used in such a way to avoid exposing successive generations of any pest to their residues. The IGRs (Esteem, Intrepid and Rimon) all target insect development but their modes of action are different making it possible to use these products in rotation with one another without selecting for insecticide resistance. The spinosyns (Success and Delegate) have the same mode of action and should not be used against successive generations. Proclaim and Altacor both have unique modes of action and will be good options to use to rotate with other insecticide classes. The biologicals (oil, granulovirus, and Bt) are also unique in the way that they kill pests, which makes them good options to use in a product rotation plan. Advanced planning will lead to better management decisions in pest control and help to ensure that Washington growers continue to have many options to use in OP-alternative pest management programs.